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ABSTRACT

The purpose of this paper is to report the results of a quasi-experimental study of the effects on student achievement resulting from the redesign of an existing anatomy course for a cohort of Occupational Therapy students. This study was based on a design strategy that combined two different instructional technology approaches to teaching and learning in lectures: (1) content-centered, World Wide Web-based hypermedia; and (2) situation-based, stand-alone hypermedia. The digital projection method of hypermedia-assisted lecture materials is described, which uses analog-assisted lecture materials within a conceptual framework incorporating "ecological psychology" and problem situations for learning. Findings are discussed in terms of content selection and presentation design guidelines derived from ecological theories of human learning. Also explored is the usefulness of this study for guiding future enhancements of medical education lecture materials. (AEF)

COMPARING STUDENT LEARNING OUTCOMES IN HYPERMEDIA AND ANALOG ASSISTED LECTURES (HAL & AAL)

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Comparing Student Learning Outcomes in Hypermedia and Analog Assisted Lectures (HAL & AAL).

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Introduction

The primary purpose of this paper is to report the results of a quasi-experimental study of the effects on student achievement resulting from the redesign of an existing Anatomy course for a cohort of Occupational Therapy students. The paper also describes a digital projection method of hypermedia-assisted lecture materials (HAL) that incorporates analog-assisted lecture materials (AAL) (e.g., 35 mm slides, glass slides, and overhead materials) within a conceptual framework incorporating ecological psychology (J. Gibson, 1986; Shaw and Bransford, 1977; Shaw and Kinsella-Shaw, 1988; Shaw, Turvey and Mace, 1982; Turvey and Carello, 1981; Turvey and Shaw, 1979; Turvey, Shaw, Reed and Mace, 1981) and problem situations for learning (Hoffman and Richie, 1997; Lave, 1990; Spiro, and Jehng, 1990; and Young, 1993). A secondary purpose of the paper is to discuss the findings in terms of content selection and presentation design guidelines derived from ecological theories of human learning. Finally the paper explores the usefulness of this study for guiding future enhancements of medical education lecture materials.

Perspectives

Medical educators have been quick to embrace the use of computers in teaching medical students, particularly the use of hypermedia-based instruction (HAI). Yet, amidst the excitement and rapid developments of this form of instructional technology, evidence of its effectiveness is sparse (McLean, 1996). At present, the professional literature focuses on either the implementation of these technologies for use as self-paced, independent instruction or as supporting instructional activities, with little attention to how instructors might best utilize hypermedia in their lectures.

This study was based upon a design strategy that combined two different instructional technology approaches to teaching and learning in lectures: 1) content-centered, World Wide Web-based hypermedia; and 2) situation-based, stand-alone, hypermedia. Each approach differs in its target application and views of epistemology. For example, the Web-based hypermedia was designed for self-paced learning and developed using a schema theory framework. The HAL

materials developed for this study were designed primarily for group learning (although available over the campus network for self-paced learning after lecture) and were developed using a situated learning framework (Young, 1993). Despite their differing theoretical frameworks, this study holds to the premise that by carefully combining existing, Web-based, hypermedia with situation-based, stand-alone, hypermedia-assisted class presentations, effective, lectures (HAL) could be developed, implemented and tested. First, we will discuss the relevant literature related to schema theory, followed by a discussion of situated learning. Finally, we will discuss how the two theoretical perspectives influenced our design of effective HALs.

Schema Theory Framework for Hypermedia Assisted Instructional Design

The schema theory framework asserts that structured hypertext and hypermedia serve to facilitate learners' assimilation and accommodation of new information into existing mental structures by providing a structured, interactive experience (Lawless and Brown, 1997). The information stored within HAI environments can be structured using a schema theory framework to form a dense or rich information space whose structure can be assimilated by learners who interact with it. Stated simply, the associations used to link nodes within the HAI will be perceived and encoded (learned) by those who interact with it.

The schema theory framework acknowledges that HAI effectiveness may be influenced by learners' "internal characteristics (e.g., prior knowledge, self efficacy, and interest) and different external constraints (e.g., learner control, instructional design and level of control)" – a view consistent with conventional perspectives of lectures (Lawless and Brown, p. 117). The control afforded learners in computerized environments refers to the extent to which learners direct the learning process. That is, learner control includes the selection and sequencing of content, display, pace, difficulty and (Merrill, 1975, 1984; Shyu and Brown, p. 86, 1992). Given the characteristics of the sample in the present study, our focus was more on the external constraints than on the internal characteristics.

Keane, Norman and Vickers (1991) argue that poorly designed hypermedia-based instruction may leave some individuals floundering within the very same information space in which they are supposed to learn. The literature offers some suggestions as to how one might help lessen the severity of the consequences of poor learner-control. Tennyson and Rothen, (1979) describe methods for structuring hypermedia content, and techniques for including

opportunities for immediate feedback and advisement, but acknowledge the fact that in general, novice learners make poor instructional decisions.

While the concept of learner-controlled instruction is not new to the use of computers as teaching aids for out-of-class or independent activities, few studies document the application of the emerging hypermedia technologies to large group instruction. Two studies used a subset of the schema theory framework, *Cognitive Flexibility Theory* (Spiro and Jehng, 1990), to design, implement, and test HAI in group and classroom settings. The first study (Spiro and Jehng, 1990) used the nonlinear aspects of HAI to control navigational features (level of control) to facilitate learners experiencing activities from multiple perspectives. They theorized that HAI could be structured so that, learners could view specific portions of the film Citizen Cane from various analytic perspectives. For example, after experiencing instructional materials that focused their attention a particular aspect of the film (e.g., film noire techniques) students' viewed and discussed a preselected film segment (situation) in small-groups. Next, navigational features programmed into the HAI directed them to another section that focused their attention on a different aspect of the film (e.g., historical influences). Afterwards, students viewed the same film segment, and engaged in small-group discussions. This process was repeated so that over time, students were afforded multiple looks at an ill-defined problem situation -- critically analyzing film. Spiro and Jehng (1990) proposed that solving ill-structured or ill-defined problems requires students to look at problems from multiple angles. They linked cognitively flexible thinking and perspective taking ability to effective problem solving (learning).

A second study confirmed the use of a cognitive flexibility framework for the design of HAI, but implemented the instruction as a self-paced, stand-alone product within a computer classroom setting. The Cognition and Instruction Group at the University of Connecticut (CIGUC, 1995) applied the cognitive flexibility framework to the design of HAI named "Auntie EMM : an Electronic Mail Mentor" Their study demonstrated how navigational design features guide students' interactive learning experiences. Moreover, this study confirmed Spiro and Jehng's perspectives for solving ill-structured problems. Students in the "Auntie EMM" study demonstrated significant increases in their levels of self-efficacy as well as their ability to use Rice Mail in a VM environment effectively. In each study, the design of HAI centered on the importance of addressing learner-control and level of control. Both proposed that programming

the computer to limit students' decisions while learning within the hypermedia environment is likely to be effective in small group and self-paced learning situations.

Friedman (1996) suggests that implementing Web-based or technology-assisted instruction within the domain of medical education may prove potentially powerful, but it may also fail. He argues that, like technologies that were once innovative and are now standard tools (e.g., 35mm slide projectors, overhead transparencies, VCRs and TVs), determining the effectiveness of new technology will require the following: 1) integrating the use of new technology into the medical school curriculum; 2) using uniform standards to judge effective use, 3) implementing instruction in ways that exploit the problem-solving and visual aspects of the medium; 4) ensuring that students are tested the on material that was taught using the new technology; 5) updating and refining hypermedia-assisted instructional programs often; and 6) designing high quality hypermedia-assisted programs. Essentially, Friedman makes a strong argument that if Web-based instruction is designed and implemented poorly, the technology will likely undermine, rather than enhance, effective instruction. As discussed earlier, the known characteristics of poorly-designed, self-paced, hypermedia can be traced to problems associated with learner-control and level of control.

Situated Learning Framework for Hypermedia Assisted Instructional Design

Situated learning (Lave, 1990; Brown, Collins and DuGuid, 1989) is related to but not limited by the tenets of Problem-based Learning (PBL). That is to say that, problems can be construed as situations but not all situations must be construed as problems. Also, some proponents of PBL espouse schema theory frameworks of human learning. The situated learning framework (Young, 1993) differs from schema theory or an objectivist approach to instructional design in that it rests on the assumption that truth, like reality, is relative to the current situation or occurs naturally. Simply put, the situated learning framework assumes that there may well indeed be "more than one right answer." In contrast, schema theoretic frameworks presuppose absolute truth. As Young, Kulikowich and Barab (1997) state:

> "What becomes clear is the assumption that concepts and principles exist independently from the students who know and use them. And the context in which they are applied is treated as incidental. This approach rests on an objectivist view that there is one truth to be known and learning is bringing each student's understanding into line with this truth (p. 134)."

According to Bridges (1992, p. 15), when compared with conventional, didactic, methods (lecture), Problem-Based Learning (PBL) or the problem-centered approach: 1) facilitates the development of "substantially more positive" attitudes toward the learning environment; 2) promotes studying for meaning rather than rote reproductions of instructor-proffered material; 3) promotes students' abilities to complete instructional programs in less time and with fewer dropouts; 4) fosters steeper growth of students' "basic knowledge of disciplines"; and 5) develops clinically competent behaviors.

Young (1993) proposed that "technology-rich" situations such as the "Auntie EMM" and "Citizen Kane" studies can be designed to facilitate learning (p. 48). In his article "Instructional Design for Situated Learning" (1993), he argues that "ideas of ecological psychology provide the background for describing four broad tasks for the design of situated learning: selecting the situations, providing scaffolding, determining and supporting the role of the teacher, and assessing situated learning" (p. 43). Hoffman and Ritchie (1997, p. 97) suggest that interactive multimedia can address some of the problems typically associated with problem-based learning, such as relying too heavily on written cases, or verbal or written vignettes; ignoring students' competition for high grades and test scores; and discounting students' initial discomfort with the increased degrees of freedom experienced in a PBL environment.

Barab, Bowdish, Young and Owen, (1997) propose that the interaction of student and HAI functions as a dyad. And like the apprentice situations discussed by Lave (1990), HAI can be designed to facilitate cognitive apprenticeships by externally representing the thinking of the HAI developers. They suggest that the discourse and co-construction process obviated by the interaction between students and HAI require designers to incorporate aspects of authentic environments to maintain what amounts to an ecological validity (Young, Kulikowich and Barab, 1997, Young, 1993, Young and McNeese, 1995).

Situating learning *scaffolds* students. When they adopt the goals posed within realistic problem-solving contexts, the net effect is a constraint to, or specification of, their intentions (Barab and Young, 1996). This specification helps learners make sense of the situation. As the informational fabric of the problem context collides with the learners' intentions, their interplay serves to obviate probable patterns or potentials for action (Shaw, Turvey and Hawkins Laboratories, 1981). Thus, problem situations and problem-solving environments can be

combined to facilitate interactions where knowledgeable behavior is literally co-determined as the properties of the student and hypermedia dynamically interact (including those of other students and/or additional sources of HAI) (Barab and Young, 1996).

Admittedly, the PBL approach in medical education does result in slightly lower performance on standardized exams (e.g., USMLE, Step I) than for students enrolled in traditional curricula (Friedman, de Blick, Sheps, Greer, Mennin, Norman, Woodward, and Swanson, 1992). However, some argue that such performance data are the result of the objective truth-based scoring rubric that emphasizes the number of "right" responses recorded on multiple-choice and short essay tests (Young, Kulikowich and Barab, 1997). This seems to confirm Friedman's (1996) suspicion that special consideration must be given to ensure that testing formats reflect accurately the content and context of teaching and learning using the new technology. If PBL centers on the entire situation, (group dynamics and problem-solving included), and traditional testing only measures students' declarative, procedural and conditional knowledge (Alexander, 1992), then hypermedia assisted lectures (HALs) may well represent an inclusive midpoint. That is, HALs seem to have the potential for facilitating students' learning specific content and skills (schema theory perspective) within authentic situations or problems (situated-learning perspective). Our belief that the use of HALs can provide instructors with a model for scaffolding students' learning by controlling both *what* is available for students' learning and the *situations* in which they learn guided the development of research questions for this study.

Research Questions

In light of the previous discussion, we posit the following research questions:

1. Will the use of HALs in a gross anatomy course produce significant differences over time between or among treatment and control cohorts with respect to participants' anatomy knowledge and laboratory practical examination scores?
2. Can participants' performance profiles (as measured by their anatomy knowledge and laboratory practical examination scores across three different occasions) be accurately classified into different treatment groups?

2a. If so, which course block (occasion) measures demonstrate the best fit with the discriminant function?

Method

The study was conducted in a private, southeastern United States medical school. The sample consisted of five cohorts (N = 162) of occupational therapy students enrolled across a period of five consecutive years (1993 - 1997) in a gross anatomy course. Three of the cohorts' archived data (1993-1995) were obtained and analyzed to control for selection bias (Cook and Campbell, 1979, p. 132). Analysis of each cohorts' group mean revealed that group performance on each of the dependent measures was consistent (see Table 1). The remaining two cohorts comprised the control group (1996, n = 30), students that completed the course following the traditional AAL format, and the treatment group (1997, n = 30), students that completed the course using the new HAL format.

Table 1: Achievement Scores Calculated Using Archived Cohort Data (1993 - 1996)

	Group Examination Mean Score
1993 Cohort (n = 30)	85
1994 Cohort (n = 37)	85
1995 Cohort (n = 36)	84
1996 Cohort (n= 30)	87

Analysis consisted of a 2X3X2 Between Groups Repeated-Measure, Multivariate Analysis of Variance (RMANOVA). Independent variables were Treatment methodology: 1, lecture type (control -AAL and treatment - HAL); and time (block-I, block-2 or block-3). Dependent measures were participants' objective/knowledge exam scores (Obj1, OBJ2 and OBJ3) and laboratory practical exam scores (Subj1, Subj2 and Subj3). A post-hoc discriminate function analysis (DFA) was conducted to investigate significant main effects to determine the degree and nature of each dependent variable's contribution to the composite (Tabachnick and Fidell, 1989).

MATERIALS

The content projected in lecture (HAL) can be understood best as a mix of existing web-based hypermedia and in-class hypermedia assisted presentations generated using Microsoft PowerPoint version 4.0. Both components (web-based and in class) were carefully integrated to yield the HAL series. Of special note is the fact that HALs facilitated the integration of instructional materials that were generated by medical faculty from various disciplines (horizontal integration) as well as medical faculty from within the discipline of anatomy from both basic science and clinical perspectives (vertical integration).

Prior to the generation of HAL materials, the existing course (anatomy for Occupational Therapy students, AAL) was carefully analyzed to establish available components suitable for control within a quasi-experimental, cohort research design for formal institutions (Cook and Campbell, 1979). Once analyzed, we implemented controls to ensure that external threats like selection bias, and internal threats such as the course content (handouts, dissection materials and textbook), assessment methodologies (e.g., knowledge exams and laboratory practicals), and instructional time schedules were identical for both groups. Our intent was to analyze instructional situations where the control group cohort experienced AAL, and the treatment group cohort experienced HAL.

With design controls in mind, we developed the interactive hypermedia presentations for classroom presentation purposes in accordance with Young's (1993) guidelines for the design of instructional materials that included the following: a) incorporate situations that afford the acquisition of material that the teacher (or designer) wishes each student to procure; b) to provide guidance or "scaffolding" for novices within the learning situation in a manner which also allows experts to operate; c) to include supporting features that allow one to track learners' progress as they access distributed information and/or works collaboratively with others thereby facilitating the skills of the designer or teacher; and d) a defined role and method of assessing learning within the presented situation. (p. 46)

We began by addressing the classroom situation itself, namely, when lecture begins. Generally, lectures begin with someone stepping up to a podium or assuming a position in front of the class and announcing that they are about to begin. We immediately thought that we could develop an opening screen which communicated the course objectives using a multimedia display. (see Figure 1a). The result was a screen that included the basic information in text (i.e., instructors name, school name, course name etc.) and more general information using graphics, sound and a Quicktime™ movie generated from the anatomical cross-sections from the Visible Human Project.

Each lecture presentation design began with a review of the objectives retained from the analog-assisted lectures (AAL) that were used with the 1996 cohort (control group). Media selection was determined by analyzing the conceptual aspects of the subject matter. For example, for concepts such as systems, a schematic drawing was a starting point to simplify and label

components of the system for subsequent investigation and instruction pertaining to the relationships between structure and function. We decided that apprenticing students to functional relationships by using schematics, illustrations, radiologic imagery, photorealistic imagery, digital video, and eventually the cadaver in the laboratory, would provide students with multiple horizontal perspectives of the lecture content (Spiro and Jehng, 1990). Additionally, relationships that described the level of analysis being displayed using the image (micro to macro) and methods for determining one's orientation between or within analytic levels were included graphically (see Figure 2). To accomplish this, images were juxtaposed, overlaid-lines connecting related images were added, and thumbnail images pertaining to previously viewed analytic levels were included. The idea was to leave obvious footprints in various ways so that students could literally see how the instructor (subject matter expert) used the information being displayed. Figure 3 provides an example of a series of screen displays used in the HALs. Furthermore, as problem-situations were presented in the form of clinical cases (Hoffman and Ritchie, 1997), students would be afforded opportunities to see how the instructor vertically integrated the basic science knowledge presented in the course (including the supporting HAI).

During this phase of the instructional design, presentation features pertaining to background color, font size, font type and generic navigational features (level of control) were standardized. Our goal was to create displays that were easy to see, consistent and easy to duplicate. Standardizing the "look and feel" of hypermedia materials (web-based and in-class) reduced production time substantially. Also, by designing one curricular component at a time, we were able to reflect upon our experiences and improve each module sequentially.

Various examples from each of the aforementioned horizontal and vertical perspectives were selected and digitized. This phase of the production process proved incredibly time consuming and detail ridden. However, we did learn that if done properly, digitized images could be re-purposed for use in several different contexts (e.g., printing, web display, texture maps, and inclusion in digital movies) and greater coherence emerged regarding the situations we planned to display. Overall, 500 new line art and photorealistic images and five Quicktime™ movies were added to the 200 images previously used in the AAL version of the course. Each image was digitally optimized and tested to ensure that it would project without being washed out by the projection process. This phase of the development/production process proved exceptionally

important as some images did tend to look different when viewed on a computer screen when contrasted with the projected image.

Near the end of our initial development phases (i.e., lectures for the first block) we realized that we hadn't addressed the end of lecture as a situation. We decided to take common elements from the opening display and convert them to yield a closing display (see Figure 1b). Closing displays consisted of a review of the behavioral objectives for the lecture displayed with text and a Quicktime™ movie comprised of selected graphics and photorealistic images presented in the lecture. Our intent was to provide an engaging summary of the lecture in a format that was easily assembled and accessed.

Once a block of HALs was completed, we revisited the level of control issues that resulted from our navigational controls and role played a prototypic instructional situation. We decided to create an index of links within PowerPoint to allow instructors and students to jump between lectures quickly and easily to promote the opportunities for classroom interactivity. We also decided to make network resident, digital copies available to students in the form of Adobe Acrobat version 3.0 Portable Document Files (PDF) for viewing after HALs had been presented. Students' responses to both the PDF and Index features of HALs were very positive. However, placing numerous image-laiden PDF files on the campus network did prompt a fair degree of concern on the part of our network administrators.

Once we finished the first block, we moved on to the second and third. In each instance, we uncovered seemingly small details associated with the design. Once again, we reflected on our previous efforts and revised where necessary. In the end, we learned that updating HALs can be done fairly rapidly. Their consistent structure and index-based accessibility made it easy to find and update lecture content -- a key piece of the argument proposed by Friedman (1996).

Results

One participant attrited from the treatment group, therefore data were obtained from 59 participants. The total cohort comparison sample entered into the RMANOVA consisted of 75% females and 25% males. Prior to beginning data analysis, Windows95-based SPSS version 7.5 (SPSS Inc., 1996) was used to test the data set against the statistical assumptions appropriate to RMANOVA and DFA.

Descriptive statistics reveal that the treatment cohort's (63%) group mean score on laboratory practical examinations were noticeably lower for the first block as compared to the control cohort's (85%) group mean score (see Table 2: Cohort groups' means and standard deviations). The treatment cohort's group mean score surpassed the control cohort's group mean score for the second block (85% and 83% respectively) but by the end of the third block, their group mean scores were identical (82% and 82% respectively).

Table 2: Cohort Groups' Means and Standard Deviations

GROUP MEAN	OBJ1	OBJ2	OBJ3	SUBJ1	SUBJ2	SUBJ3
Control	.82	.95	.89	.85	.83	.82
Treatment	.80	.95	.97	.63	.85	.82
Total	.81	.95	.93	.74	.84	.82
GROUP SD	OBJ1	OBJ2	OBJ3	SUBJ1	SUBJ2	SUBJ3
Control	.075	.039	.054	.098	.090	.087
Treatment	.079	.029	.034	.115	.095	.105
Total	.077	.034	.059	.154	.092	.096

Results obtained from RMANOVA with Wilks criterion, revealed that the combined DVs were significantly affected by lecture type for both within-subject, $\underline{F}$ (4, 226) = 26.58, $p < .001$, and between-subject effects, F (2, 56) = 13.95, $p < .001$. The results reflected a strong association between lecture format and the combined DVs across occasions, $\eta^2 = .54$, and within occasion, $\eta^2 = .33$ (see Table 3: RMANOVA for cohort groups' objective and laboratory examination scores across three instructional blocks).

A post-hoc, step-wise discriminant function analysis (DFA) was conducted (see Table 4: Classification Results, Table 5: Stepwise DFA Statistics and Table 6: Summary of Canonical Discriminant Functions) to determine whether participants' performance profiles could be useful to classify future cases into lecture-type groups and to evaluate which block measures demonstrated a best-fit with the statistical function (Tabachnick and Fidell, p.479, 1989).

Results revealed that participants' profiles could improve prediction by 91% (adjusted with Cohen's Kappa) over and above chance (Cohen, p 29, 1978). Pooled within-groups correlations between discriminating variables and canonical discriminant functions revealed that participants' first-block laboratory practical exam scores (r = .73) and third-block knowledge exam scores (r = - .58) demonstrated the best-fit with the derived function followed by participants' third-block laboratory practical exam scores (r = .18), first-block knowledge exam scores (r = .13), second-block knowledge exam scores (r = -.10), and second-block laboratory practical exam scores (r = .08).

Table 3: RMANOVA for Cohort Groups' Objective and Laboratory Examination Scores Across Three Instructional Blocks

Omnibus Effect

$F(4, 226) = 29.19$; $p < .001$ Effect Size = .50; Noncent 229.5; Power 1.00

Effect	DF	F	Significance	Effect Size	Noncent	Power
Group by Block	4,54	29.18	.000	.68	116.57	1.00
Block	4,54	60.33	.000	.82	241.32	1.00

Table 4: Classification Results

		Predicted Group Membership	
Actual Group	No. of Cases	Control	Treatment
Control Cohort Group	30	28 93.3%	2 6.7%
Treatment Cohort Group	29	2 6.9%	27 93.1%

Percent of "grouped" cases correctly classified: 93.22%
Cohens Kappa adjustment for chance probability: 91%

Table 5: Stepwise DFA Statistics

		Wilks' Lambda				Exact F			
Step	Entered	Statistic	df1	df2	df3	Statistic	df1	df2	Sig
1	Subj1	.469	1	1	57	64.44	1	57	.000
2	Obj3	.320	2	1	57	59.49	2	56	.000

Note: a - Minimum partial F to enter is 3.84

b - Maximum partial F to remove is 2.71

Table 6: Summary of Canonical Discriminant Function

Function	Eigen Value	% of Variance	Cumulative %	Canonical Correlation
1	2.124	100	100	.825

Standardized Canonical Discriminant Equation

D = -.69(Objective Examination Block 3 Score) + .82(Lab Practical Block 1 Score)

Unstandardized Canonical Discriminant Equation

D = 8.34 -15.17(Objective Examination Block 3 Score)+ 7.67(Lab Practical Block 1 Score)

Discussion

Our study was guided by the three research questions posed on page 8 of this paper. Each is addressed in terms of our findings in the paragraphs that follow.

Will the use of HALs in a gross anatomy course produce significant differences over time between or among treatment and control cohorts with respect to participants' anatomy knowledge and laboratory practical examination scores? The results revealed that at the end of the course, participants' cumulative performances on objective/knowledge examinations were significantly higher for participants taught with HAL (Mean = 90.3%) than with AAL (Mean = 88.7%). However, participants' cumulative laboratory practical examination scores revealed a significantly opposite pattern (HAL Mean = 76.3 and AAL Mean = 83.3). We submit that lower laboratory performance scores are a direct result of students' struggle to adapt to the redefining of their roles as learners in lecture during the first block of the course. The fact that they are equally able to apply their knowledge in the laboratory in both the second and third block seems to suggest that instructors might consider increasing the number of examinations to guard against mathematically penalizing their students as they adjust to their new roles.

Second, the doubly-multivariate RMANOVA design implemented in this study helped to measure participants' performance on knowledge and laboratory practical examinations in a manner that accommodated time both statistically and practically (i.e., provided time for participants' role redefinition). Careful analysis of the profile of participants' performance on exams (both objective and practical) throughout the course suggested that Pina and Savenye's (1992) argument regarding changes in roles warrants further investigation. The data obtained for this study revealed that over time, participants' block scores for each of the dependent measures described significantly different performance patterns. For example, it was hypothesized that HAL participants' performance measures would suffer initially (block one) due to changes in expectations of students' roles as learners that are often associated with situated learning environments. Indeed, participants from the treatment cohort (HAL) did exhibit significantly lower mean performance scores for the first block (HAL 79, 63 and AAL 82, 85) but, they did change significantly by the end of the second (HAL 95,84 and AAL 95, 83) and third blocks

(HAL 97, 82 and AAL 89, 82). The results here suggest that students adjusted to new roles and expectations and ultimately enhanced their learning and performance on course measures.

Third, the conceptual framework that was used to design the HAL series predicted that participants' ability to apply the content would be enhanced because the HAL format incorporated principles of situated learning and cognitive flexibility. While a tendency might be to review only cumulative results of students' performance on course measures, examining student learning outcomes through the use of performance profiles provides a much richer and accurate description of the influence of instructional innovations such as HALs.

Can participants' performance profiles (as measured by their anatomy knowledge and laboratory practical examination scores across three different occasions) be accurately classified into different treatment groups? Results of the RMANOVA and discriminate function analysis (DFA) demonstrate clearly the power of repeated measures to detect statistically significant differences in students' performance profiles. The accuracy of the DFA (91%), after adjusting for chance probability (Cohen's Kappa, 1978) supports strongly the effectiveness of HAL for enhancing students' learning outcomes. Methodologically, the RMANOVA and DFA are useful tools for detecting levels of effectiveness for instructional innovation such as HAL, especially in situations when students are organized as learning cohorts.

If so, which course block (occasion) measures demonstrate the best fit with the discriminant function? Students' performance on the first block laboratory practical examination represented the best fit with the discriminant function. This result reinforces the notion that students' experience changes in their role perceptions and need time to adjust. The only other measure to enter the stepwise DFA was the third block (occasion) knowledge examination score. These results reinforce the degree of learning enhancement expected in using HALs. Also, the findings here lend support to the notion that students need clarity about role expectations and specific encouragement to assume active learning roles early in the course. Clearly, the results of this study offer a model for examining the effectiveness of instructional technology and raise new questions about the nature of learning environments that exist and may be found in lectures – traditional and hypermedia-assisted. For example, to what extent are instructors and students, individually and collectively, responsible for facilitating effective teaching and learning processes? How do instructor actions influence student involvement and vice versa? To what extent does

hypermedia encourage or constraint interactions and active involvement -- within class and outside of class? Does HAL extend hypermedia in a way that meaningfully enhances learning environments beyond the traditional classroom walls?

Conclusions and Future Directions

Our design framework (HAL) posits that an intermediary (the instructor) can generate appropriate matches between problems (i.e., clinical cases) and problem-solving environments (e.g., HAI) by linking or integrating lecture materials with existing Web-based hypermedia. Through careful content organization (as detailed by schema theory) and high-fidelity problem representation (Young, 1993), HALs can be developed in such a way that the instructor can effectively broker learner-control and level of control within a traditional lecture setting. We believe that careful use of the multiple perspective-taking techniques described by Spiro and Jehng, (1990) combined with the situational design guidelines of Young (1993) can provide scaffolding, determine and support the role of the teacher, and utilize outcome-based assessments of the learning environment (situation) in a manner which takes into account achievement measures. The HAL approach capitalizes on the idea that instructors can facilitate student interactions and active involvement in lecture settings. In many ways, expectations for student interaction and active involvement have been reserved for small groups and PBL formats. The sequencing of content, and how and when it is displayed in HALs can provide effective scaffolds upon which the raison d'etre of teaching and learning are made obvious to the learner. Pina and Savenye (1992) submit that much of the danger associated with PBL can be traced to significant changes in the teacher's role due to the increase in learner-control in teaching and learning processes. The HAL approach affords both students and instructors a mediated environment where they can gradually adjust to the new format and roles prompted by HAL. The nonlinear structure, information, and control embedded within HAL increase the degrees of freedom available for instructors and students compared to AAL. The difference is that the situated learning principles incorporated in HALs help students understand the relevance of course content information because it is presented within realistic situations.

We are prompted to reflect on Friedman's requirement that new technologies must be integrated into the curriculum in a way that high quality, up-to-date, hypermedia-assisted materials are used, and managed realistically, in teaching learning, and assessment. That is, the

content and context for teaching and learning are reflected in the same way for testing what students have achieved. Friedman argues that this also includes authoring *programs*. In this study, our instructional design was based upon the idea that presentation software (e.g., Microsoft PowerPoint 4.0) can be used to generate what amounts to a midpoint between two relatively well-known extremes: 1) the detailed programming requirements of authoring self-paced HAI; and 2) the relative ease of using interactive multimedia to generate situated learning materials (e.g., HALs). Therefore, new developments in presentation software (e.g, . Microsoft PowerPoint 4.0) offer realistic ways for interested instructors to manage teaching, learning, and testing with hypermedia.

Conclusions drawn from this study may be useful to other medical schools contemplating the development or re-purposing of lecture materials and methodologies. Additionally, the findings and conclusions of this study seem to be applicable to a wide variety of higher education settings. The use of specific elements of content selection and presentation design strategies derived from ecological theories of human learning (Young, 1993) and quasi-experimental, cohort-based research designs (Cook and Campbell, 1979) hold promise for action-oriented research and assessment within formal educational institutions. It also suggests a need to both replicate and extend the study on a larger scale to examine its effectiveness across institutional settings, content domains, and delivery mechanisms (e.g., distance learning).

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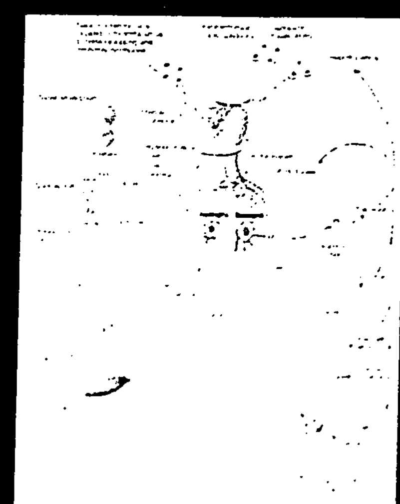
A

Endocrine System

Part 1



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Department of Anatomy
Tulane University School of Medicine

HYPOPHYSIS

B

FIGURE 22

FIGURE 2

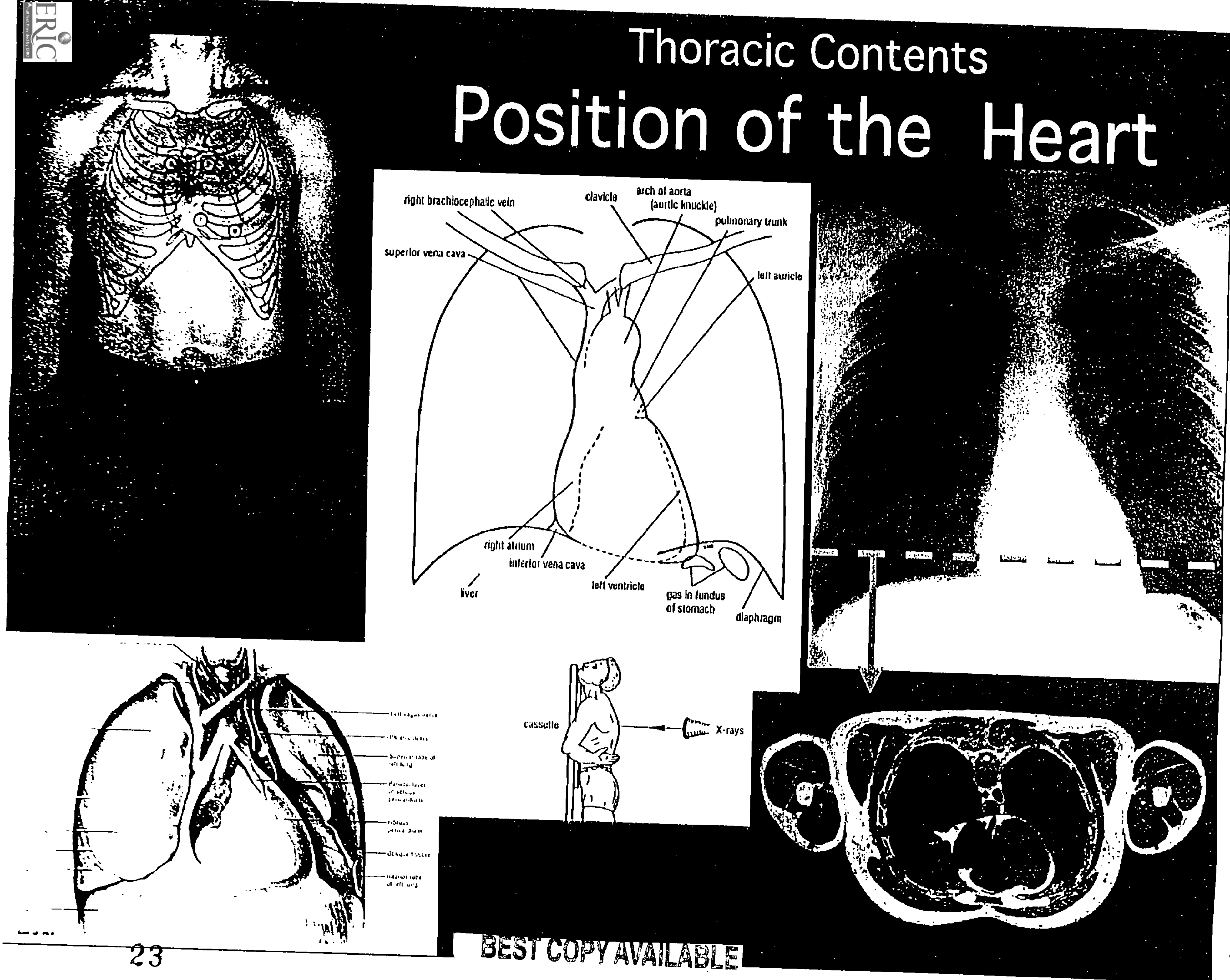
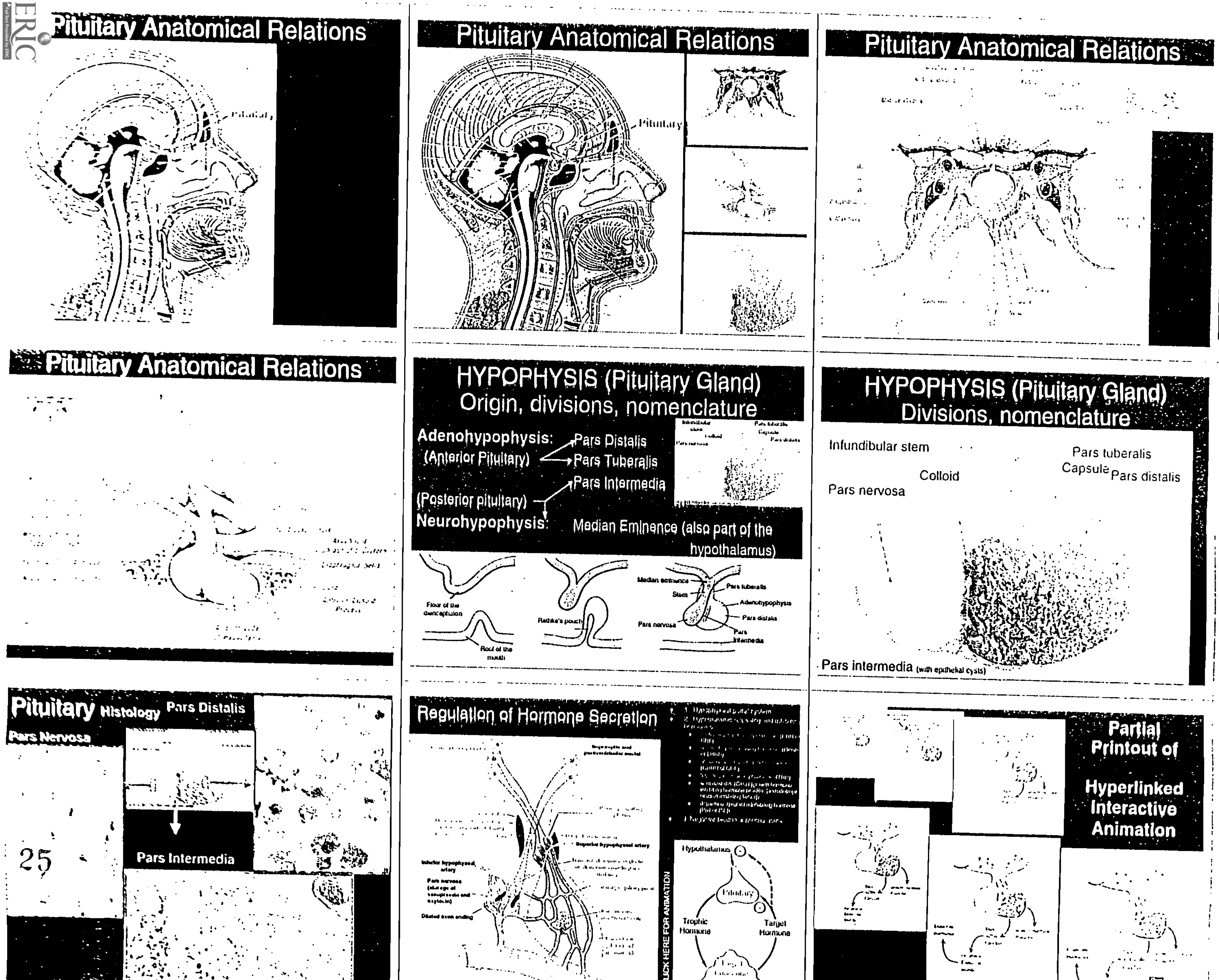

Thoracic Contents
Position of the Heart
right brachiocephalic vein
superior vena cava
clavicle
arch of aorta
(aortic knuckle)
pulmonary trunk
left auricle
right atrium
inferior vena cava
liver
left ventricle
gas in fundus
of stomach
diaphragm
cassette
X-rays

FIGURE 3


Pituitary Anatomical Relations
Pituitary
Pituitary Anatomical Relations
Pituitary
Pituitary Anatomical Relations
Pituitary Anatomical Relations
HYPOPHYSIS (Pituitary Gland)
Origin, divisions, nomenclature
Adenohypophysis:
(Anterior Pituitary)
Pars Distalis
Pars Tuberalis
Pars Intermedia
(Posterior pituitary)
Neurohypophysis:
Median Eminence (also part of the hypothalamus)
Floor of the diencephalon
Roof of the mouth
Rathke's pouch
Median eminence
Stem
Pars tuberalis
Adenohypophysis
Pars distalis
Pars nervosa
Pars intermedia
HYPOPHYSIS (Pituitary Gland)
Divisions, nomenclature
Infundibular stem
Pars tuberalis
Colloid
Capsule
Pars distalis
Pars nervosa
Pars intermedia (with epithelial cysts)
Pituitary Histology Pars Distalis
Pars Nervosa
Pars Intermedia
Regulation of Hormone Secretion
Superior hypophyseal artery
Inferior hypophyseal artery
Dilated axon ending
Hypothalamus
Pituitary
Trophic Hormone
Target Hormone
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Partial Printout of
Hyperlinked Interactive Animation

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